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THE EFFECT OF CONTEXTUALIZED VS. DECONTEXTUALIZED ILLUSTRATIONS ON ATTENTION ALLOCATION AND CREATIVE TRANSFER IN ENERGY-SAVING COMMUNICATION

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Abstract. *Effective dissemination of energy-saving information is vital for fostering environmental awareness and behavioral change. This study explored how diagram type and individual environmental attitudes shape attention allocation, text processing, and information transfer. A mixed-methods experiment was conducted with 60 design students, who viewed two types of explanatory diagrams—Contextualized Application Illustrations (CAI) and Decontextualized Technical Illustrations (DTI)—while their eye movements were recorded. Participants then created hand-drawn posters and completed semi-structured interviews. Results showed that CAI captured attention more quickly than DTI, as indicated by shorter time to first fixation, regardless of environmental attitude. A significant interaction effect emerged for fixation time: high-attitude participants focused less on CAI images but engaged more deeply with accompanying text, whereas low-attitude participants devoted more attention to CAI images but less to text. Poster analyses revealed a strong preference for CAI as a creative reference, with participants integrating contextual cues into their designs. Interviews further confirmed that CAI's real-life scenarios enhanced intuitive comprehension and stimulated scenario-based creative expression. Overall, contextualized visual design proved effective in attracting attention, supporting deeper cognitive processing among high-involvement viewers, and facilitating the transfer of environmental information into new expressive formats.*

Keywords: *eye tracking, contextualized illustration, environmental attitude, information transfer, energy-saving communication*

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Introduction

Background

The dissemination of energy-saving and emission-reduction information in university campuses plays a crucial role in fostering students' environmental awareness and behaviors. In a campus context, enabling faculty and students to "see, understand, and be willing to act" requires energy conservation information to be presented clearly and effectively, thereby enhancing its visibility and comprehensibility. Visual materials such as graphics, charts, and schematic diagrams are indispensable in science education and communication; their design directly affects how audiences perceive and understand information (Wood & Stocklmayer, 2020). In environmental knowledge dissemination, schematic diagrams are particularly important as core media tools. Two common modes of graphical presentation are Decontextualized Technical Illustrations (DTIs) and Contextualized Application Illustrations (CAIs). DTIs typically strip away specific contexts to highlight physical mechanisms or technical principles in a simplified form, while CAIs embed information within everyday scenarios or operational processes to enhance intuitiveness through contextual cues (Sun et al., 2025). In other words, DTIs emphasize the "physical/mechanistic" dimension of content, whereas CAIs highlight the "operational/contextual" dimension. While both have their advantages, it remains unclear which approach is more effective—and in what ways—in communicating campus energy conservation concepts.

A key challenge in such visual–verbal energy information dissemination is how viewers allocate attention between images and text. The allocation pathway of attention directly influences comprehension and learning outcomes (Gatcho et al., 2024; Mao et al., 2024). Focusing exclusively on images or text may prevent audiences from forming a complete understanding of the underlying energy-saving principles. Only by effectively integrating image and text information can audiences construct accurate mental models

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and deepen comprehension (Yang et al., 2013). Different presentation formats (e.g., CAI vs. DTI) may also affect the depth of understanding and the transfer of knowledge to practical applications: for instance, CAIs may make it easier for viewers to apply acquired knowledge to daily life or design practice (Mao & Benbasat, 1998), whereas DTIs may better highlight principles but lack cues for practical association (Jitendra et al., 2011). These potential differences involve the entire process from attention to comprehension, transfer, and even behavioral intention. However, little is currently known about how audiences distribute attention between images and text, or how different formats influence subsequent knowledge transfer and behavioral intentions.

Theoretical Framework

Cognitive psychology and multimedia learning theory provide the conceptual foundation for addressing these questions. According to Multimedia Learning Theory (Mayer, 2019) and Dual Coding Theory (Clark & Paivio, 1991), presenting information in combined visual and verbal forms enables the coordinated use of visual and verbal channels, thereby enhancing comprehension. Pairing explanatory diagrams with explanatory text facilitates the creation of connections between visual and verbal representations, effectively improving knowledge acquisition (Jian & Ko, 2017; Mao et al., 2024) It is generally believed that viewing the image before reading the text can reduce cognitive load, as the image provides an intuitive overall framework, followed by textual elaboration to deepen understanding (Parekh, 2025). This principle is embedded in Cognitive Load Theory recommendations for multimedia design, which advise avoiding split attention between text and image and promoting smooth transitions of attention between the two (Sweller, 2011). Excessive irrelevant details can increase extraneous cognitive load and hinder learning. Thus, traditional design often advocates simplifying images and removing "seductive details" to reduce unnecessary cognitive burden (Klepsch & Seufert, 2021; Park et al., 2011). However, recent studies suggest that moderate inclusion of contextual details does not necessarily increase cognitive load and may, in some cases, improve learning outcomes. For example, an experimental study comparing anatomy instructional diagrams with varying realism levels found that adding a moderate amount of realistic detail improved learning performance without the expected increase in cognitive load (Skulmowski, 2024). In some cases, fully simplified schematics even made spatial information extraction more difficult, resulting in higher subjective cognitive load compared to versions with basic contextual cues. This finding suggests that contextual cues, if closely related to the learning content, may function as prompts that help organize information, thereby reducing extraneous load and facilitating comprehension, rather than serving merely as distractions (Chen & Chang, 2024; Ramadhani et al., 2023).

From the perspective of situated cognition and contextualized information processing, learning is more effective when it occurs in specific contexts, and the acquired knowledge is more easily transferred to similar contexts (Bahari et al., 2023). Applied to the present study, CAIs present information through familiar daily-life scenarios and operational processes, potentially improving both comprehensibility and contextual relevance. For example, adding familiar environmental backgrounds to a biological life cycle diagram significantly increased perceived relevance and strengthened concern for environmental issues (Wood & Stocklmayer, 2020). Such contextual elements make it easier for audiences to relate diagram content to their own experiences, thereby "understanding" and valuing the embedded environmental information. In contrast, DTIs emphasize technical principles but lack scene cues, which may require higher levels of abstract reasoning to interpret and apply (Warouw et al., 2024). In sum, CAIs, by reflecting real-life contexts, may lower comprehension barriers and increase the likelihood of knowledge transfer, whereas DTIs, by focusing on mechanistic principles, may impose higher cognitive demands for contextual integration in the absence of situational cues. These assumptions require empirical testing.

To explore attention and information processing in greater depth, the present study employs eye-tracking metrics to quantify how audiences allocate attention when viewing image–text materials. Eye-tracking technology objectively records gaze durations and sequences on stimuli, enabling inferences about cognitive processing (Alemdag & Cagiltay, 2018; Ban et al., 2024; Mao & Zhang, 2024). Two classic indicators were selected: Fixation Time (FT) and Time to First Fixation (TFF). FT refers to the cumulative duration of gaze within a specific Area of Interest (AOI), with longer durations generally indicating deeper information processing, greater cognitive resource investment, and often higher comprehension or interest (Feng, 2009). Conversely, very brief fixations may indicate insufficient processing. TFF refers to the elapsed time from stimulus onset to the first fixation on a specific AOI. Shorter TFFs suggest that an element has higher visual salience and can rapidly capture attention (Cao et al., 2024), whereas longer TFFs indicate lower visual prominence, making the element more likely to be noticed later or overlooked entirely. Analysis of these two metrics makes it possible to determine whether audiences initially focus on images or text under different diagram types and to assess where greater cognitive effort is invested.

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Research Aim and Research Questions

Overall, existing literature has predominantly focused on the immediate comprehension or persuasive effects of visualized environmental information. For example, one study used eye-tracking combined with questionnaires to examine attention distribution between text and images in posters or advertisements, as well as their effect on memory and attitude change (Walker et al., 2020). Their eye-tracking analysis of environmental public service posters found that viewers typically fixated first on prominent slogan text before attending to images; when posters paired positively framed slogans with negative warning imagery, memory rates were highest. This suggests that the pairing of text and images influences attention order and persuasive effect. However, few studies have systematically compared CAIs and DTIs in terms of their differential effects across the full "attention–comprehension–transfer" chain in environmental communication. Most prior work has focused on static cognitive outcomes (e.g., comprehension tests, recall scores) or attitude change (Ban et al., 2024), with limited simultaneous examination of online attention allocation and offline behavioral outputs. Moreover, no research has specifically examined whether audiences transfer and re-represent information learned from diagrams into their own creative outputs. This gap includes the lack of objective coding frameworks and empirical data on such transfer. Additionally, in terms of eye-tracking AOI aggregation, there is a scarcity of direct empirical evidence comparing attention allocation between image and text regions. In other words, it remains unclear whether CAIs and DTIs direct more attention to images or text, and how such macro-level attention distribution patterns influence the comprehension and application of information.

Building on the above background and theoretical framework, this study aims to explore how contextualized and decontextualized illustrations, together with individual environmental attitudes, influence attention allocation, text processing, and the transfer of information. To achieve this, the following research questions were formulated:

RQ1: What effects do diagram type (CAI vs. DTI) and environmental attitude (Higher vs. Lower) have on viewers' fixation time (FT) and time to first fixation (TFF) at the image and text levels?

RQ2: What effect does diagram (CAI vs. DTI) have on participants' transfer and re-representation of information in subsequent environmental poster creation?

RQ3: What effects do diagram type (CAI vs. DTI) and environmental attitude (Higher vs. Lower) have on participants' cognitive processes when viewing image–text materials and creating posters, as revealed through post-experiment interviews?

Research Methodology

General Background

This study was conducted between March and May 2025 at a university in central China. All data collection took place in a controlled laboratory environment to ensure consistency and reliability. The scope of the research focused on undergraduate design students in their second and third years, as this group possesses both foundational training and active engagement in visual communication practices. The study adopted a mixed-methods design, combining quantitative and qualitative approaches to explore the effects of two types of schematic diagrams—DTI and CAI—on learners' visual attention and environmental poster expression, and to assess the interaction effect of environmental attitude. The quantitative component collected visual and subjective data through eye-tracking and coded analysis of poster outputs, while the qualitative component employed semi-structured interviews to explore the effect of diagram type on participants' cognitive processes when interpreting diagrams, designing poster content, and articulating their environmental motivations.

Participants

A total of 60 undergraduate students (second- and third-year) majoring in design from a university in central China participated in the study (aged 18–22 years). To control for potential gender effects, the sample included 30 male and 30 female participants. All participants had normal or corrected-to-normal vision, no severe color vision deficiencies, and no contraindications for eye-tracking participation. The choice of design students was intentional,

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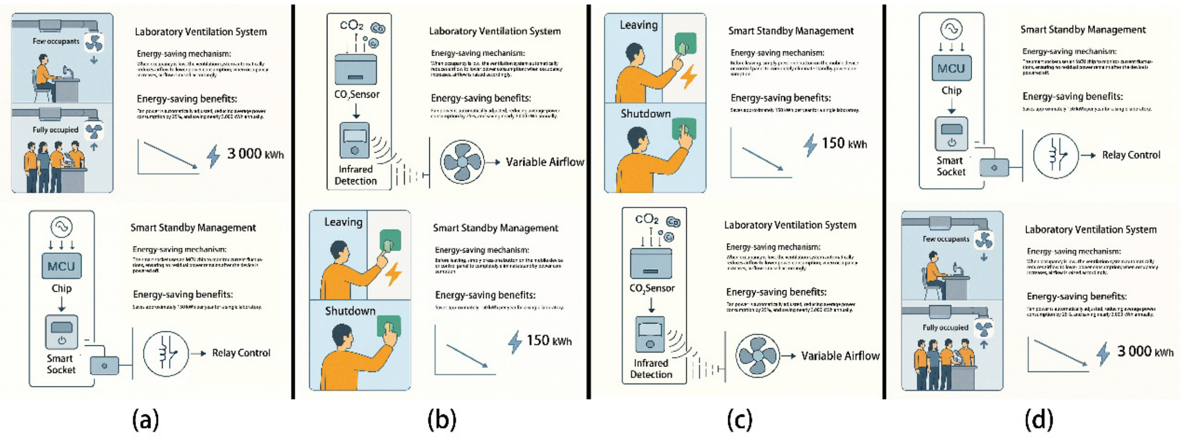
as they possess foundational training in visual communication and are accustomed to interpreting image–text materials, making them a suitable group for examining visual attention and creative transfer. All procedures complied with the guidelines for research involving human participants. Participants were invited through campus announcements and class group postings, and participation was entirely voluntary. Informed consent was obtained in writing prior to the study. Participants were assured that their responses and outputs would remain anonymous, that no personal identifiers would be collected, and that they could withdraw from the study at any time without penalty. Each participant received a small gift valued at approximately USD 5 as compensation for their time.

Stimuli

Two topics were selected as stimuli for the experiment: *laboratory ventilation system* and *smart standby management*. Each topic illustrated both the energy-saving mechanism and the energy-saving benefit, using both image and text. For each topic, two versions were developed: a CAI and a DTI. In the DTI version, the images contained no human figures, and the energy-saving mechanism description focused on physical principles. In contrast, the CAI version included scenarios showing people operating the equipment, and the energy-saving mechanism description emphasized operational principles. The textual descriptions of the energy-saving benefits were identical across both versions. All text in the stimuli was presented in Chinese.

Each participant viewed one DTI and one CAI stimulus, corresponding to different topics (*laboratory ventilation system* and *smart standby management*). There were four possible combinations of stimuli (Figure 1), and participants were randomly assigned to one of the combinations to minimize learning effects.

Figure 1
Example Translations of the Four Stimulus Combinations: (a), (b), (c), and (d)



All stimuli were divided into five AOIs, as shown in Figure 2. AOI 1 represented the first schematic diagram, AOI 2 was the title, AOI 3 was the text description of the energy-saving mechanism, AOI 4 was the text description of the energy-saving benefit, and AOI 5 was the second schematic diagram.

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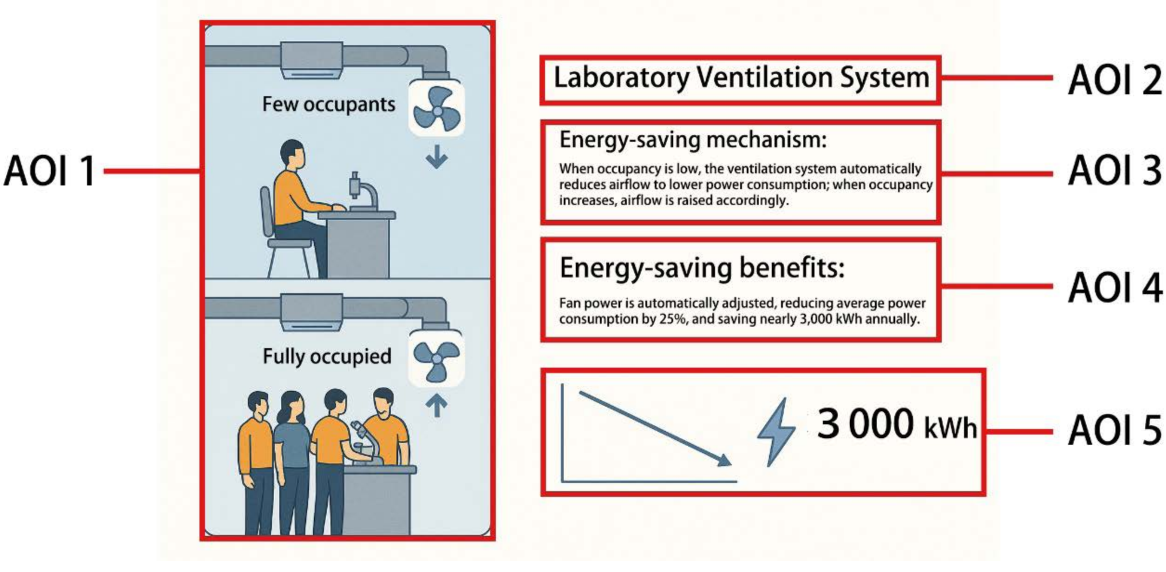
Figure 2
AOI Layout



Note. Example shows for the CAI version of laboratory ventilation system

Instrument and Procedures

Eye movement data were recorded using a Tobii Pro Fusion eye tracker with a sampling rate of 250 Hz. Stimuli were displayed on a 27-inch monitor with a refresh rate of 144 Hz and a resolution of 2560 × 1440 pixels. A Philips VTR5910 audio recorder was used to capture participants' verbal statements, and a Canon EOS R500 camera was used to photograph the hand-drawn posters.

The Environmental Action Scale (EAS) was designed to measure the degree of participation in civic actions aimed at producing collective effect on environmental issues (Alisat & Riemer, 2015). The EAS consists of two dimensions—"participatory actions" and "leadership actions"—and includes 18 items. The scale has demonstrated good reliability and validity, with a Cronbach's alpha coefficient of .92 and item-total correlations ranging from .43 to .80. Participants were asked to rate all 18 EAS items in response to the question: "Have you participated in the following environmental activities and actions?" Items were rated on a 5-point Likert scale from 1 (never), 3 (sometimes), to 5 (often).

The semi-structured interview protocol comprised three main sections—"viewing experience," "poster creation," and "environmental motivation"—covering a total of nine questions (Table 1).

Table 1
Interview Protocol

No.	Section	Question
1	Viewing experience	What was your first impression when you first saw the two schematic diagrams?
2		Which areas or elements did you focus on first while viewing? Why?
3		How do you think the two diagrams differ in terms of information content and ease of understanding? Which one feels more "user-friendly"?
4	Poster creation	Why did you choose certain knowledge points as the theme of your poster?
5		How did you allocate your visual attention between graphical symbols (e.g., icons, arrows) and textual descriptions?
6		How did you integrate "environmental thinking" into your poster content?

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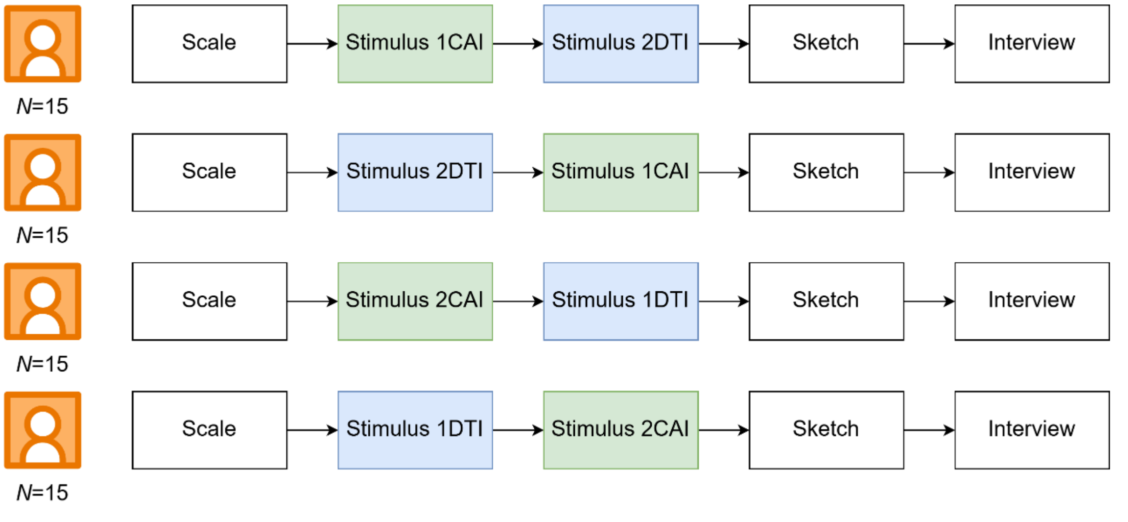
No.	Section	Question
7	Environmental motivation	During the creation process, what inspired your interest or sense of responsibility for energy conservation and environmental protection?
8		What energy-saving actions do you think the audience would be motivated to take after viewing your poster? Why?
9		Which expressions (numbers, slogans, or stories) do you think would most move the audience? Why?

Before the experiment, all participants were randomly assigned to one of four groups (15 participants per group), each corresponding to a different stimulus combination. Participants were briefed on the experimental procedure and precautions, and eye tracker calibration was completed. As shown in Figure 3, the procedure began with participants completing the EAS. They then viewed two energy conservation and environmental protection images related to the university campus, each for 30 seconds, while eye movement data were recorded. After viewing, they selected one topic to create a draft poster promoting energy conservation and environmental protection. The tools provided included A3 paper, fine-liner pens, and colored markers. The creation process was limited to 30 minutes. Finally, participants took part in a semi-structured interview. The entire process lasted approximately 60–90 minutes.

Figure 3
Experimental procedure



Data Analysis

Descriptive statistics were performed on the EAS results. Based on the median score, participants were categorized into high-EAS and low-EAS groups. For each AOI, FT and TFF were extracted. The five AOIs were grouped into images (AOI 1 + AOI 5) and text (AOI 2 + AOI 3 + AOI 4), and FT and TFF were calculated separately. Image FT was the sum of FT for all corresponding AOIs, and image TFF was the lowest TFF value among those AOIs. Text FT and TFF were calculated in the same way.

Based on the topic chosen for their poster, participants were identified as referencing either a CAI or a DTI stimulus. The hand-drawn posters were quantitatively coded using a scoring approach. Two dimensions were used for image coding: (1) content, including working principle and energy-saving effect; and (2) presentation style, including CAI and DTI. This coding focused solely on the information and presentation style of the poster, without evaluating design quality. For each occurrence of content related to the working principle in the poster, one point was added to the working principle score; the energy-saving effect was scored similarly. In graphical expression, if a realistic scene was present, one point was added to the CAI score; if a decontextualized technical illustration appeared, one point was added to the DTI score. Figure 4 shows an example of the coding and scoring. To ensure

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accuracy, two researchers independently coded the posters and calculated the scores, resolving disagreements through discussion. SPSS 26.0 was used for quantitative data analysis.

Figure 4
Example of One Participant's Hand-drawn Poster and the Coding and Scoring

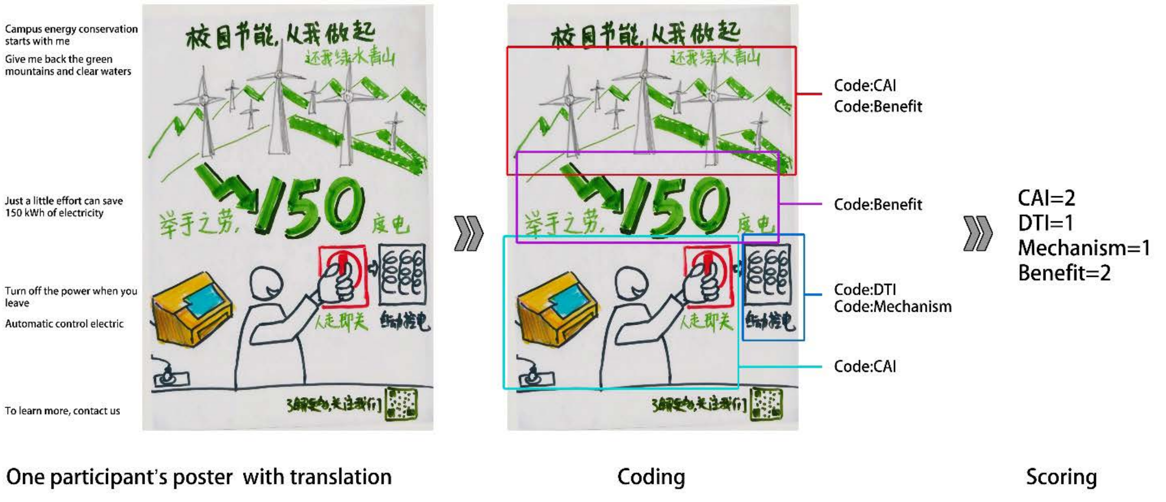

Diagram type was treated as an independent variable, and environmental attitude as a moderator, in a two-way ANOVA for the dependent variables (FT, TFF). The main effect of diagram type was analyzed, as well as the interaction between diagram type and environmental attitude. Content and presentation style were also treated as independent variables, and independent-samples t-tests were conducted on the coding scores to determine whether there were significant differences between working principle and energy-saving effect scores, as well as between CAI and DTI scores. Statistical significance was set at $p < .05$.

Audio recordings were transcribed verbatim, and thematic analysis was applied to code the interview data. Similar codes were grouped into potential themes, such as "information readability," "balance between symbols and text," and "triggering environmental emotions." Coding was performed independently by two researchers, and discrepancies were resolved through discussion.

Research Results

Eye Movement

The descriptive statistics for FT in images are shown in Table 2. The main effect of environmental attitude was significant, with the higher-EAS group (M = 4.51, SD = 1.78) significantly lower than the lower-EAS group (M = 4.91, SD = 1.14), $F(1, 116) = 4.340$, $p = .039$, $\eta^2 = .036$. The main effect of diagram type was also significant, with CAI (M = 4.11, SD = 1.55) significantly lower than DTI (M = 5.20, SD = 1.20), $F(1, 116) = 39.383$, $p < .001$, $\eta^2 = .253$. The interaction between environmental attitude and diagram type was significant (Figure 5), $F(1, 116) = 84.122$, $p < .001$, $\eta^2 = .420$. Follow-up simple effect analyses (Table 3) indicated that within the higher-EAS group, CAI was significantly lower than DTI, whereas within the lower-EAS group, CAI was significantly higher than DTI. Within CAI, the higher-EAS group was significantly lower than the lower-EAS group; within DTI, the higher-EAS group was significantly higher than the lower-EAS group ($p < .05$).

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Table 2
Descriptive Statistics of FT in Images

Environmental Attitude	Type	*M (s)*	*SD*	*N*
	CAI	3.03	1.01	30
	DTI	6.00	0.95	30
Higher	Total	4.51	1.78	60
	CAI	5.19	1.21	30
	DTI	4.64	1.02	30
Lower	Total	4.91	1.14	60
	CAI	4.11	1.55	60
	DTI	5.32	1.20	60
Total	Total	4.71	1.51	120

Figure 5
Interaction Effect for FT in Images

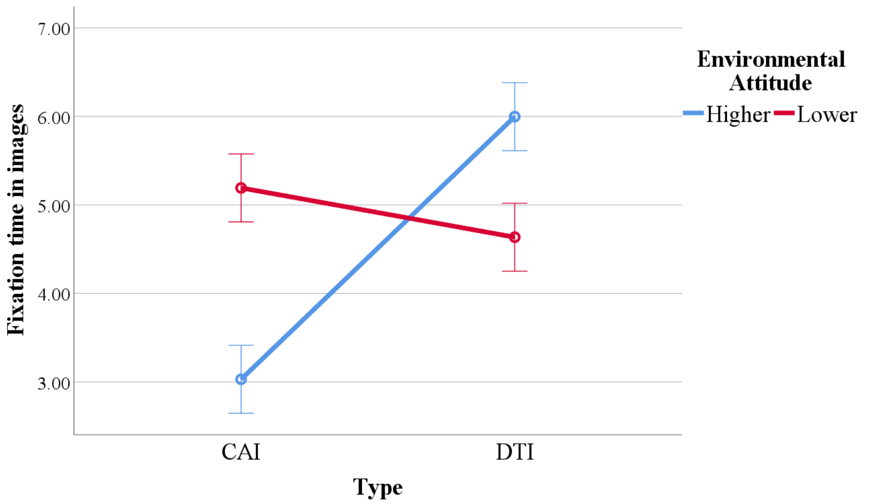

Table 3
Simple Effect Analysis for FT in Images

Variable		I	J	Mean Difference (I-J)	F	p
Environmental Attitude	Higher	CAI	DTI	-2.967	119.311	< .001
	Lower	CAI	DTI	.556	4.194	.043
Type	CAI	Higher	Lower	-2.162	63.337	< .001
	DTI	Higher	Lower	1.362	25.124	< .001

The descriptive statistics for FT in texts are shown in Table 4. The main effect of environmental attitude was significant, with the higher-EAS group (M = 12.52, SD = 1.00) significantly higher than the lower-EAS group (M = 9.53, SD = 1.15), $F(1, 116) = 291.232$, $p < .001$, $\eta^2 = .715$. The main effect of diagram type was not significant ($p = .897$). The interaction between environmental attitude and diagram type was significant (Figure 6), $F(1, 116) = 33.286$, $p < .001$, $\eta^2 = .223$. Simple effect analyses (Table 5) showed that within the higher-EAS group, CAI was significantly higher than DTI, whereas within the lower-EAS group, CAI was significantly lower than DTI. Within CAI, the higher-

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EAS group was significantly higher than the lower-EAS group; within DTI, the higher-EAS group was significantly higher than the lower-EAS group ($p < .05$).

Table 4
Descriptive Statistics of FT in Texts

Environmental Attitude	Type	*M (s)*	*SD*	*N*
Higher	CAI	13.01	0.89	30
	DTI	12.02	0.86	30
	Total	12.52	1.00	60
Lower	CAI	9.01	1.01	30
	DTI	10.05	1.05	30
	Total	9.53	1.15	60
Total	CAI	11.01	2.23	60
	DTI	11.03	1.38	60
	Total	11.02	1.84	120

Figure 6
Interaction effect for FT in texts

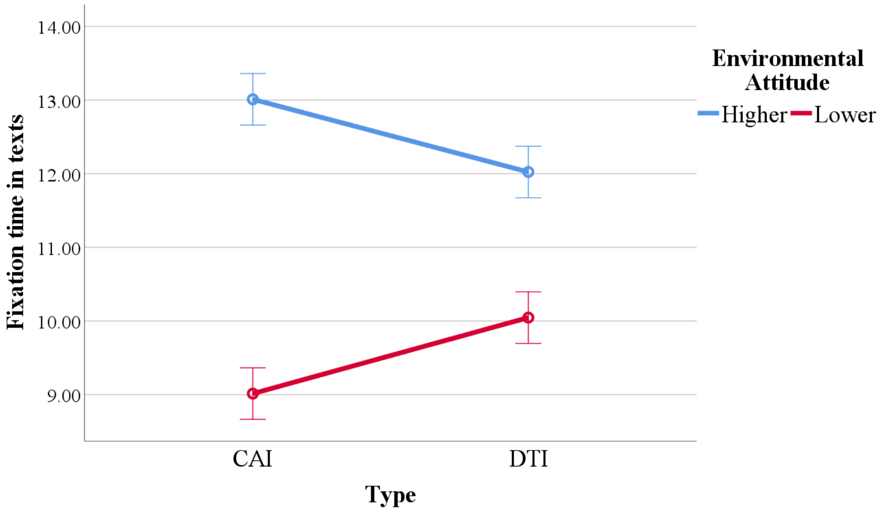

Table 5
Simple Effect Analysis for FT in Texts

Variable		*I*	*J*	Mean Difference *(I-J)*	*F*	*p*
Environmental Attitude	Higher	CAI	DTI	.987	15.903	< .001
	Lower	CAI	DTI	-1.032	17.397	< .001
Type	CAI	Higher	Lower	3.996	260.711	< .001
	DTI	Higher	Lower	1.977	63.804	< .001

The descriptive statistics for TFF in images are shown in Table 6. The main effect of environmental attitude was not significant ($p = .678$). The main effect of diagram type was significant, $F(1, 116) = 119.378$, $p < .001$, $\eta^2 = .207$. The interaction between environmental attitude and diagram type was not significant ($p = .255$).

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Table 6
Descriptive Statistics of TFF in Images

Environmental Attitude	Type	*M (s)*	*SD*	*N*
	CAI	0.33	0.13	30
	DTI	0.49	0.09	30
Higher	Total	0.41	0.14	60
	CAI	0.31	0.06	30
	DTI	0.50	0.04	30
Lower	Total	0.40	0.11	60
	CAI	0.32	0.10	60
	DTI	0.49	0.07	60
Total	Total	0.41	0.12	120

The descriptive statistics for TFF in texts are presented in Table 7. The main effect of environmental attitude was not significant (p = .162). The main effect of diagram type was not significant (p = .068). The interaction between environmental attitude and diagram type was not significant (p = .182).

Table 7
Descriptive Statistics of TFF in Texts

Environmental Attitude	Type	M (s)	SD	N
	CAI	1.11	0.18	30
	DTI	1.23	0.23	30
Higher	Total	1.17	0.22	60
	CAI	1.11	0.22	30
	DTI	1.12	0.17	30
Lower	Total	1.12	0.20	60
	CAI	1.11	0.20	60
	DTI	1.18	0.21	60
Total	Total	1.14	0.21	120

Poster Coding

A total of 41 participants chose CAI stimuli as a reference during the hand-drawn poster creation stage, while 19 participants chose DTI stimuli.

For the 41 participants who selected CAI stimuli, the coding results are shown in Table 8. In terms of content, there was no significant difference between *mechanism* and *benefit* (p = .182). In terms of presentation, CAI scores were significantly higher than DTI scores (t = 4.96, p < .001).

Table 8
Coding Results for Posters from the 41 Participants Who Selected CAI Stimuli

Variable		*N*	*M*	*SD*	*t*	*p*
	Mechanism	41	1.78	0.82	1.345	.182
Content	Benefit	41	1.51	0.98		
	CAI	41	2.56	0.95	4.96	< .001
Presentation	DTI	41	1.46	1.05		

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For the 19 participants who selected DTI stimuli, the coding results are shown in Table 9. In terms of content, *mechanism* scores were significantly lower than *benefit* scores (t = -2.518, p = .016). In terms of presentation, there was no significant difference between CAI and DTI scores (p = .521).

Table 9
Coding Results for Posters from the 19 Participants Who Selected DTI Stimuli

Variable		*N*	*M*	*SD*	*t*	*p*
Content	Mechanism	19	2.16	0.69	2.518	.016
	Benefit	19	1.63	0.60		
Presentation	CAI	19	1.58	0.69	-.648	.521
	DTI	19	1.74	0.81		

Interviews

Thematic analysis of the interview data yielded three main themes: "Viewing Experience," "Poster Creation," and "Environmental Motivation." The following presents the interview results for each theme, illustrated with representative quotes (H or L indicates that the quote is from a participant in the higher- or lower-environmental-attitude group, respectively).

All participants reported that when viewing the two schematic diagrams, their attention was first drawn to the images and only then to the accompanying text. Many noted that images conveyed information and caught the eye instantly, while the text served to provide further detail. For example, one lower-EAS participant stated: *"I usually notice the picture first; it's more intuitive and eye-catching. I just glance at the text to check the title and a few key points."* (L15) After an initial scan of the image, participants turned to the textual explanation for deeper information; however, the degree of careful reading differed between groups. Higher-EAS participants generally read the text more thoroughly to ensure they understood the mechanisms and energy-saving details conveyed by the diagrams. In contrast, some lower-EAS participants admitted to only skimming the text. As one higher-EAS participant remarked: *"After looking at the picture, I read all the text carefully because I want to understand the energy-saving principles and benefits it describes."* (H21) Conversely, another lower-EAS participant shared: *"I don't usually read the explanation word-for-word—just get the gist and then start thinking about something else."* (L3)

Regarding the amount of information and ease of understanding, most participants felt that the CAI was more relatable to daily life and more "user-friendly," whereas the DTI was denser in information and somewhat harder to understand. Several lower-EAS participants openly described feeling information overload when facing technical diagrams and preferred the intuitive scenes shown in contextual illustrations. *"The lab one without people (DTI) is too technical; I felt a bit confused. In contrast, the one with people (CAI) makes it easy to understand the energy-saving action at a glance."* (L13) On the other hand, some higher-EAS participants expressed strong interest in technical diagrams, noting that although DTI was slightly more complex, it provided more in-depth details about the principles, which they found appealing. *"Although the contextual diagram is more intuitive, I'm actually more interested in the details of the technical diagram because it explains the underlying working principle."* (H14) This difference suggests that higher-EAS participants were more willing to invest effort in understanding complex information, while lower-EAS participants preferred more direct and vivid image–text presentations.

In the subsequent poster creation stage, the vast majority of participants chose CAI as the reference for their poster content. Interviews revealed that the common reason for choosing CAI was that its scenes were closer to everyday life, making it easier to conceptualize and adapt. One lower-EAS participant explained: *"When designing the poster, I used the one with a scene (CAI) as a reference because scenes with people feel more relatable and make it easier to imagine how to draw it."* (L22) Similarly, a higher-EAS participant stated: *"The contextual diagram has a sense of daily life; I think it's more approachable, so I designed my poster based on that everyday scene so the audience can understand it at a glance."* (H8) In contrast, the few who chose DTI as a reference often did so out of preference for its clear structure and emphasis on principles. As one higher-EAS participant noted: *"I used the technical diagram (DTI) as my template because I prefer that kind of clear, structured diagram that can explain the principle in detail."* (H15)

Regardless of which diagram they referenced, participants generally favored a contextualized mode of expression in their posters to enhance effect. Many reported adding specific scenes or human figures to depict energy-saving behaviors, aiming to increase audience immersion. *"When drawing the poster, I deliberately added a*

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small everyday-life scene, like a student turning off appliances in standby mode, so that viewers would connect it to their own lives." (H12) Even those referencing technical diagrams mentioned incorporating real-life elements to increase relatability, rather than listing only abstract technical details.

Participants also commonly drew information from the stimulus materials for their poster creation. Many directly borrowed effective elements from the diagrams, such as eye-catching icons, key numbers, and wording, to ensure the poster was accurate and persuasive. *"I also wrote the numbers from the diagram into my poster, like the percentage of electricity saved, to make it more convincing so people can immediately see the energy-saving effect."* (L24) Some mentioned adopting iconic symbols from the source material, such as plugs and arrows, to maintain visual consistency and intuitive comprehension. *"The unplugging icon from the diagram was really vivid, so I just drew it into my poster."* (L6) In balancing text and imagery, most followed the principle of "image-led, text-supported," using concise text alongside images to convey messages. *"I prefer to have the image present the core idea, with a small amount of text to explain, so the poster content is more intuitive and clear."* (H13) Overall, participants emphasized borrowing relatable contexts and key information from the original materials, and balancing image and text to improve readability and persuasiveness.

Participants' motivation for energy conservation and environmental protection was further stimulated during the poster creation process. Many mentioned that creating the poster enhanced their environmental awareness. Several higher-EAS participants said the process reinforced their pre-existing sense of responsibility. *"While creating the poster, I felt my sense of responsibility was triggered. Designing the poster reminded me that I should set an example in saving energy."* (H16) Some lower-EAS participants noted that they learned new energy-saving knowledge through the process, sparking interest and addressing previous gaps in awareness. *"Honestly, I didn't pay much attention to energy saving before, but during the poster drawing, I learned some things and now feel it's actually quite important."* (L18) Thus, regardless of initial attitudes, participants were to some extent moved during the creative process, developing more positive emotions and understanding toward energy conservation.

Participants also envisioned possible actions the audience might take after viewing their posters, revealing their desire to influence others through their work. Most hoped the posters would encourage simple energy-saving actions, especially in daily campus life. *"I hope that after seeing the poster, classmates will also turn off unused devices, just like I drew in my poster."* (H23) Some emphasized the specific benefits or outcomes of energy saving to increase appeal. One lower-EAS participant explained: *"I highlighted the benefits of saving electricity in my poster, so people would see the real advantages and be more willing to act."* (L5)

Regarding which expressions would most move the audience, opinions varied but provided valuable insights. Some felt that detailed data were the most persuasive. As one higher-EAS participant pointed out: *"I think specific numbers are most convincing because they let people see directly how big an impact energy saving can have."* (H14) Others emphasized emotional or story-based messages as more resonant. As one lower-EAS participant stated: *"Compared to dry numbers, a small everyday story can touch people's hearts more."* (L17) A few mentioned the role of short, powerful slogans, believing that a catchy phrase could quickly grab attention and leave a lasting impression. Overall, the interviews indicate that whether through personal environmental awareness or strategies to influence audiences, participants from both higher and lower environmental attitude groups engaged in deeper reflection on energy-saving communication during this creation process—valuing both vivid, relatable presentation and effective content delivery, in line with the quantitative results showing differences in image–text preference.

Discussion

Interpretation of Key Findings

This study compared the effects of CAI and DTI in the presentation of energy-saving information, focusing on their ability to capture attention, facilitate text processing, and promote information transfer. The findings demonstrated clear advantages of CAI over DTI. First, in terms of attention capture, CAI was more effective in attracting participants' initial gaze: eye-tracking data indicated that the TFF on CAI images was significantly shorter than on DTI images (0.32 s vs. 0.49 s). This difference was unaffected by environmental attitude, suggesting that contextualized scenes are inherently more visually compelling (Mao et al., 2024; Specht, 2007).

Second, regarding sustained attention allocation, there was a significant interaction between diagram type and environmental attitude. Among participants with higher environmental attitudes, fixation time on CAI images was significantly shorter than on DTI images. In contrast, among lower-attitude participants, FT was longer for CAI than for DTI, indicating that they spent more time browsing CAI images before shifting to text. Similarly, for text

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processing, participants with higher environmental attitudes spent significantly more time reading text overall, reflecting deeper central processing tendencies (Jian, 2017; Mao et al., 2024). However, the diagram type modulated this pattern: higher-attitude participants allocated significantly more FT to text in the CAI condition than in the DTI condition, whereas lower-attitude participants allocated significantly less FT to text in the CAI condition compared to the DTI condition. This suggests that CAI stimulated deeper reading of textual details among highly environmentally conscious participants, while reducing the reliance on text among those with lower environmental attitudes.

Third, in terms of information transfer and application, CAI again showed advantages. The vast majority of participants chose CAI content themes for creative transfer in their poster design (Abdullah et al., 2024; Son & Goldstone, 2009). This strong preference indicates that CAI content is more easily understood, remembered, and transformed into new forms of expression. Moreover, coding of poster designs revealed that participants referencing CAI incorporated original contextual elements to a significantly greater extent than technical elements (CAI-style scores were significantly higher than DTI-style scores). Conversely, participants referencing DTI did not emphasize technical elements in their work; many instead incorporated contextualized expressions (no significant difference between CAI- and DTI-style scores). This pattern indicates that participants tend to transfer contextualized information into their creations and present knowledge points in a contextualized manner. In other words, the perceptual-to-expressive transfer was more pronounced in the CAI condition (Abdullah et al., 2024; Yang et al., 2020). By contrast, information derived from DTI, lacking intuitive context, often required participants to supplement it with contextual elements during re-creation, or led them to focus on easily communicated energy-saving outcomes while neglecting technical principles (Anwar et al., 2019; Yan & Lavigne, 2014). Indeed, analysis of posters from the 19 participants who chose DTI showed that they conveyed significantly more benefit-related information than mechanism-related content. This further underscores CAI's advantage in promoting comprehensive information transfer: contextualized diagrams help learners grasp both "how it works" and "why it matters," rather than retaining only conclusive outcomes.

These findings align with and extend prior literature and theoretical perspectives. On one hand, the greater attention-capturing ability of CAI supports the view from visual cognition research that attention is guided by semantic meaning rather than solely by visual salience—eye movements are drawn to meaningful regions of a scene rather than to purely conspicuous features (Boardman & McCormick, 2022). By embedding people and everyday scenarios into images, CAI illustrations offer richer semantic cues and contextual meaning, thereby capturing observers' gaze more quickly than abstract technical diagrams. This is consistent with earlier studies showing that meaningful contextual information is more powerful in attracting visual attention than cluttered, visually salient elements (Calvo & Meseguer, 2002).

On the other hand, the results suggest that the effects of contextual elements on information processing are more complex and should be considered in relation to learner characteristics. According to the seductive details effect and cognitive load theory, adding irrelevant or excessive details to learning materials can divert attention from core content, hindering comprehension and memory (Park et al., 2011; Sweller, 2011). Research on adult learners has shown that illustrations or additional elements unrelated to learning objectives can increase cognitive load and reduce learning outcomes (Eng et al., 2020). At first glance, CAI's inclusion of human and situational details might be considered an increase in "extra" information that could interfere with comprehension. However, the findings did not show that CAI impaired overall understanding; rather, it enhanced processing under specific conditions. For higher-attitude participants, CAI did not distract from text processing but instead prompted more in-depth reading, suggesting that contextual information in this case served as meaningful background supporting comprehension (Kaoropthai et al., 2023).

This aligns with the educational concept of context-based learning, which posits that placing abstract knowledge in concrete application contexts helps learners link new information with prior experiences, thereby reducing comprehension difficulty and enhancing readability and engagement (Avargil et al., 2012; Rose, 2012). Interview findings supported this: many participants reported that diagrams with operational contexts were "more intuitive and user-friendly" and easier to digest. For lower-attitude participants, CAI reduced their text reading time—possibly indicating less deep processing—but they could still obtain key information from images and reproduce it in their creations. Thus, CAI can attract the attention of low-involvement individuals by increasing situational interest (Chesnov, 1996), and even without deep text processing, it can facilitate initial understanding and transfer.

Conversely, in the DTI condition, the lack of contextual cues forced lower-attitude participants to rely more on text to obtain information. Although their total reading time increased, comprehension was not necessarily improved, as seen in their tendency to avoid complex principles and focus on outcomes during creation. This reflects the classic Elaboration Likelihood Model, which posits that individuals with high motivation (e.g., high

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environmental attitude) tend to adopt the "central route" to carefully process key information (Petty & Cacioppo, 1986). They can self-regulate attention to extract useful details from text and are not easily distracted by surface cues. In contrast, low-motivation individuals are more likely to follow the "peripheral route," where attention is drawn by intuitive and pleasant elements (Kitchen et al., 2014). In the present study, lower-attitude participants were more likely to be attracted by CAI's vivid contextual scenes, investing less effort in textual details—consistent with peripheral processing's sensitivity to visual cues (Vater et al., 2022). Fortunately, because CAI's images were thematically relevant, participants could still grasp the main message. However, in the absence of such cues in DTI, these participants had to shift toward central processing by necessity, increasing text attention; yet due to low interest and motivation, their processing of dense text may have remained superficial, leading to incomplete understanding and transfer of technical principles (Zobel et al., 2024).

In sum, this study empirically demonstrates the interaction between contextual design and learner characteristics: contextualized diagrams are effective for engaging low-involvement learners and lowering comprehension barriers, but may limit them to surface-level processing; for high-involvement learners, contextualized design does not impede deep processing and may instead help them quickly identify key points and invest in detailed text learning. Overall, the findings contribute to the literature on effective image–text material design by supporting the theory that visual attention is driven by meaning rather than visual salience, and by expanding understanding of the seductive details effect—showing that when contextual details are tightly aligned with the topic and serve comprehension goals, they can function as cognitive scaffolds rather than distractions, offering a new perspective for the design of educational and communication materials.

Theoretical and Practical Implications

The present findings clarify when and for whom contextualization exerts effects: the diagram type determines the entry point of attention and the image–text trade-off, while environmental attitude moderates depth of textual processing and the likelihood of creative re-expression. It is acknowledged that the present evidence was obtained from only two campus energy-saving topics; effects may differ for more complex or abstract environmental issues (e.g., carbon capture, biodiversity loss). Accordingly, the implications advanced below should be read as topic-bound and will benefit from future tests across a broader set of themes.

First, the results reveal a significant interaction between information presentation format (contextualized vs. decontextualized) and learner characteristics (environmental attitude), expanding the theoretical framework in cognitive psychology and environmental education regarding how individual differences affect information processing. Previous research in environmental psychology has shown that environmental attitudes and prior interest influence individuals' attention to and depth of processing of environmental information (Wang et al., 2022). However, such studies have mostly focused on text-only messages or static images, rarely examining the combined effects of information design factors and individual factors. By using eye-tracking evidence, this study demonstrates that when design factors change the visual intuitiveness of information, audience attitudes modulate attention allocation and cognitive processing routes. This finding resonates with and extends the applicability of the Elaboration Likelihood Model in the context of visual environmental communication—traditional ELM emphasizes that audience motivation levels determine their tendency to adopt either central or peripheral processing routes (Kitchen et al., 2014; Petty & Cacioppo, 1986). The study further shows that the visual presentation format of information itself can guide audiences to switch between processing routes or compensate for motivational deficits. For example, contextualized illustrations can temporarily draw low-motivation individuals into the message context, thereby increasing their engagement. This suggests that persuasion theories should place greater emphasis on the role of visual cue design and the interaction between individual factors and information design (Son & Goldstone, 2009).

Second, this study provides new empirical support and supplementary insights for multimedia learning theory. According to the cognitive theory of multimedia learning, the combination of text and images can facilitate dual coding and thus improve comprehension, provided that visual and verbal elements are coordinated and unnecessary distractions are avoided (Mayer, 2014). The results show that, when teaching complex energy-saving principles, integrating appropriate contextualized images helps learners form intuitive representations of abstract concepts, reinforcing the effects of textual explanations. This finding supports the contextualization and concreteness principles in multimedia learning: compared to purely technical diagrams, placing principles within specific application scenarios provides additional semantic connections, reducing comprehension difficulty (Alemdag & Cagiltay, 2018). That said, the present advantage was observed within the tested topics and with a creative-transfer

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task; models of multimedia learning would benefit from incorporating topic complexity/familiarity and audience involvement as moderators.

Furthermore, in terms of research methodology, this study integrates eye-tracking, product content coding, and qualitative interviews into a "triangulated" evidence chain to depict the effects of information presentation on the entire attention–comprehension–application process. Such cross-method integration is still rare in the relevant field. Eye-tracking data revealed real-time attention allocation and reading patterns; poster creation outcomes reflected the extent of knowledge internalization and transfer; interviews provided supporting evidence for subjective experiences and motivational changes. As such, the study established a research paradigm spanning from perceptual input to behavioral output, extending the methodological scope of design cognition research. Importantly, the creative task indexes near transfer in an isomorphic format (poster-to-poster re-representation) rather than actual energy-saving behaviors—the ultimate goal of environmental communication. Future applications should therefore pair contextualized materials with low-friction behavioral opportunities (e.g., opt-ins to energy challenges, QR-code pledges) and longitudinal follow-ups to verify movement from comprehension to measurable action. The theoretical significance of this paradigm lies in the emphasis that evaluating the effectiveness of an instructional or communication design should not be limited to immediate attention or test scores but should also assess whether the audience truly internalizes the content and can transform it into new expressions or actions. The findings indicate that creative tasks can reveal whether knowledge transfer occurs, providing valuable reference points for future educational intervention studies. Nonetheless, translating re-expression into real-world conservation behaviors remains a necessary next step.

From a practical perspective, this study offers concrete guidance for energy-saving communication and environmental education in higher education. First, the results clearly show that contextualized visual presentations are superior to purely technical explanations when communicating energy-saving principles and measures. This means that when designing promotional materials (e.g., energy-saving guides, science popularization boards, posters, new media content), abstract principles should be embedded in concrete scenes through illustrations whenever possible (Drymiotou, 2021). For example, instead of only providing structural diagrams and textual explanations of equipment, pairing them with real-life scenarios or human operation contexts will more effectively attract attention and enhance intuitive comprehension (Jian, 2017). This contextualized design is particularly important for audiences with low environmental engagement: as shown in this study, university students with low environmental interest are less likely to spend time studying complex technical details, but vivid scene imagery in materials can encourage them to linger and absorb key information (Mao et al., 2024). Given the topic-bounded nature of the present evidence, future campus campaigns should pilot-test materials across multiple environmental themes—ranging from concrete, proximal issues to abstract, systemic ones—to ensure applicability beyond the two topics examined here.

Second, contextualized presentations should complement rather than replace textual explanations. The analysis showed that students with high environmental attitudes read text more deeply after viewing intuitive images, whereas those with low attitudes, although reading less after viewing images, still grasped the general meaning. This suggests that text remains the primary vehicle for conveying in-depth information, and environmental education materials in higher education should not sacrifice textual accuracy and clarity for visual appeal (Alemdag & Cagiltay, 2018; Richter & Scheiter, 2019). In practice, concise textual descriptions or data points can be placed alongside contextualized illustrations, allowing highly interested readers to delve deeper while enabling less interested readers to glean the main idea from the visuals alone.

Third, the poster creation results indicate that engaging audiences in creative activities facilitates the leap from cognition to behavior. Most students, after viewing energy-saving information, were able to re-express what they had learned through poster design, incorporating their own ideas—often with particularly rich contextualized expressions. Therefore, higher education environmental programs could incorporate more interactive and participatory activities, such as designing environmental posters, producing energy-saving videos, or conducting scenario simulation projects (Ajit, 2021; Khalil et al., 2023). Such practices not only assess students' knowledge acquisition but also encourage them to integrate environmental concepts into their professional expertise and daily life, achieving unity between knowing and doing. For example, design students can be encouraged to create campus energy-saving design projects, deepening their understanding of conservation measures through the creative process and internalizing environmental awareness as part of their professional competence. These activities should be paired with observable behavioral endpoints (e.g., participation rates, energy-use dashboards), enabling evaluation of actual conservation outcomes.

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Finally, the findings have implications for audience-segmented environmental communication strategies. Given that environmental attitudes influence message reception, communication content should be tailored to audience characteristics: for groups with weak environmental awareness and limited knowledge reserves, materials should focus on simple, vivid contextual cases and avoid overly technical details at the outset, to prevent disengagement due to high comprehension barriers; for groups with stronger environmental interest or relevant backgrounds, more in-depth technical principles and data can be provided, as they are both willing and able to engage deeply with the content. In the context of universities, first-year students and non-environmental majors may require more lifestyle-oriented environmental education approaches, while environmental majors or members of environmental clubs can benefit from more professional and detailed training. In short, designing information with precision based on audience attitudes and cognitive differences can significantly enhance the effectiveness of environmental communication and education.

Meaningfulness and Contributions

This research carries both theoretical and practical significance in the field of environmental communication and education. Theoretically, it establishes that contextualized illustrations, moderated by individual environmental attitudes, have clear effects on attention allocation, text processing, and creative transfer. By integrating eye-tracking evidence with creative production and interviews, this study deepens the understanding of how visual–verbal integration operates across the entire chain of attention, comprehension, and application. It extends multimedia learning theory and the Elaboration Likelihood Model by showing that visual design features can interact with personal attitudes to guide different cognitive processing routes.

Methodologically, the study contributes a triangulated approach that combines objective eye-movement data, creative transfer tasks, and qualitative reflections. This mixed-methods design demonstrates how multiple layers of evidence can be used to evaluate not only immediate comprehension but also the re-expression and application of knowledge—an area often overlooked in previous research.

Practically, the findings matter in the context of university sustainability education. Campus energy-saving communication often faces the challenge of limited attention and motivation among students. The results of this study provide evidence-based strategies: contextualized illustrations attract and sustain attention, lower comprehension barriers, and enable learners to integrate environmental principles into creative expression. These insights offer actionable guidance for designing targeted and effective educational interventions that foster environmental awareness and promote sustainable behavior in higher education communities.

Limitations and Future Research Directions

First, the most significant limitation lies in the sample composition. All participants were undergraduate students majoring in design. This group typically possesses relatively high visual literacy and image–text comprehension skills, which may amplify the advantages of contextualized diagrams and thus restrict the generalizability of the findings to other disciplines or to the general public. Future studies should recruit cross-disciplinary and community samples (including science, engineering, social sciences, humanities, and non-university populations), measure visual literacy and domain knowledge as covariates, and conduct subgroup and interaction analyses (e.g., with environmental attitude and cognitive style) to develop audience-segmented design guidance.

Second, the scope of topics was narrow. Only two campus energy-saving themes were examined, which limits the applicability of the findings to more complex or abstract environmental issues (e.g., carbon capture, biodiversity loss). Future research should adopt a factorial design that manipulates diagram type (CAI vs. DTI) across topics varying in complexity and familiarity, thereby mapping the boundary conditions of contextualization effects.

Third, the transfer outcome reflected near transfer in an isomorphic format. The creative transfer task (poster design) assessed re-representation and application in a similar format to the stimuli, but it did not capture real energy-saving behaviors, which represent the ultimate goal of environmental communication. Future work should: (a) include validated scales for behavioral intention, self-efficacy, and goal commitment; (b) embed low-friction behavioral choices (e.g., energy challenge sign-ups, QR-code pledges, audit registrations, checklist downloads); (c) record objective behavioral traces (participation logs, energy dashboard interactions); and (d) conduct longitudinal follow-ups and field A/B experiments to test causal effects on observable and sustained conservation behaviors.

Fourth, the laboratory setting and fixed 30-second viewing time limited ecological validity. Standardizing exposure enhanced internal validity, but it did not accurately reflect the fleeting and self-directed nature of real-world

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attention. Future studies should implement field experiments in natural contexts (e.g., randomized placement of posters or digital signage on campus) using mobile eye tracking, passive dwell-time logging, and intercept surveys (including recall, comprehension, and attitudes) to enhance both external and ecological validity.

Fifth, the operationalization of contextualization involved multiple correlated elements. The manipulation combined presence of human figures, background richness, and text placement/signaling, which limits conclusions about which elements drive the observed effects. Future experiments should adopt multifactor designs to disentangle features and test a graded continuum from purely technical to highly contextualized materials, in order to identify optimal balance points for different audiences.

Finally, supporting reproducibility and translation to practice is essential. Future research should pair contextualized diagrams with concise, co-located textual signals and openly share stimuli, coding schemes, and (pre) registered analyses. These steps will enable cumulative evidence across topics and populations, clarifying when and for whom contextualization yields benefits that extend beyond re-expression to measurable behavior change.

Conclusions and Implications

This study has confirmed the significant effects of diagram type and environmental attitude on attention, information transfer, and cognitive processing in the dissemination of energy-saving messages. CAI attracted initial attention more rapidly than DTI, and the interaction with environmental attitude shaped how viewers distributed their attention between images and text. CAI also showed a clear effect on transfer, as most participants re-applied contextual cues from these materials in their poster designs, producing richer and more relatable expressions. Furthermore, interviews revealed that contextualized visuals supported intuitive comprehension and scenario-based expression, while environmental attitude determined the depth of textual engagement. Together, these results establish that contextualized design, moderated by individual attitudes, exerts strong effects on how learners attend to, understand, and re-express environmental information, offering valuable insights for educational communication.

The research provides practical implications for educational practice in higher education. Universities should design energy-saving communication materials using contextualized, image–text integrated approaches; align visuals with concise textual explanations; and introduce participatory activities such as poster design or scenario-based projects. Moreover, stratified strategies should be applied to different audience groups, tailoring materials to their levels of environmental involvement.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Zhengzhou University of Light Industry (2025-004-039). Informed consent was obtained from all subjects involved in the study.

Declaration of Interest

The authors declare no competing interest.

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